Profile monitors for the Super-FRS*

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Profile monitors providing precision measurement of horizontal and vertical beam profiles are essential for transport and targeting of Super-FRS beams.

Introduction

At GSI the beam monitoring technique based on Secondary Electron EMission (SEM) is routinely used for the high power UNILAC beams. When charged particles hit a metallic surface, secondary electrons are liberated, escaping from it forming a measurable signal. Wire SEM grids are widely used as device to measure the profile of the ion beams. While the yield probability of secondary electron emission is low, these devices can produce signal up to 10nC/wire in case of SIS beam. At FAIR beam intensities, e.g. $4.5\text{x}10^{11}$ ^{238}U/spill, beam passing through the wire, undergoes to a significant energy loss (few GeV) even if the particle are not stopped, and wires can be damaged by the temperature rise. Presently, SEM-grids of different material and geometry satisfying the Super-FRS beam parameters are under investigation.

Beam test

A standard GSI monitor DG1010 [1] designed with wire spacing and diameter of 1.5 mm and 0.1 mm, respectively, was installed in vacuum at the first focal plane F1 of the FRS and irradiated with U beam. The number of horizontal and vertical W wires was 16. To simulate an experimental condition similar to that of the Super-FRS, the wire signals were transported over a long cable (length >50 m). A current-to-frequency converter QFW POLAND [2] was used to measure the profile of the beam. The electronics was triggered by the start of extraction TTL pulse delivered by the accelerator timing system.

The response of the detector was studied with slow-extracted $^{238}U^{73+}$ beam at 300 MeV/u and fast-extracted $^{238}U^{29+}$ beam at 125 MeV/u. At higher energy the beam intensity did not exceed $2.8\text{x}10^{8}$ ions/s. At lower energy the maximum intensity delivered by the SIS18 was equal to 10^{10} ions/spill. Due to the small area of the detector one single charge state distribution per time could be measured by the grids. The intensities of the different charge states of the beam were simulated and compared with the measured ones. The horizontal profile of $^{238}U^{90+}$ beam reaching F1 with a magnetic rigidity of 8.085 Tm corresponded to a measured charge of 0.19 nC. The U charge state distribution produced in 40 μm of Ti material inserted at the FRS target position was estimated by using the GLOBAL code [3]. The emission of secondary electrons from the W surface was calculated by the Sternglass formula [4]. Under the assumption that 7% of the beam crossed the wires, the estimated charge was 1.46 times the measured one.

The response of the detector to fast-extracted beam was tested after adding a capacitance of 4.7 nF to stretch the pulse.

The 3D measurement of a time-resolved beam profile of $^{238}U^{88+}$ at about 125 MeV/u, reaching F1 after impinging a 10 μm Ti foil, is shown in Figure 1. The ratio between measured and simulated charges decreased up to 0.36 for the maximum intensity (assuming no losses up to the FRS target).

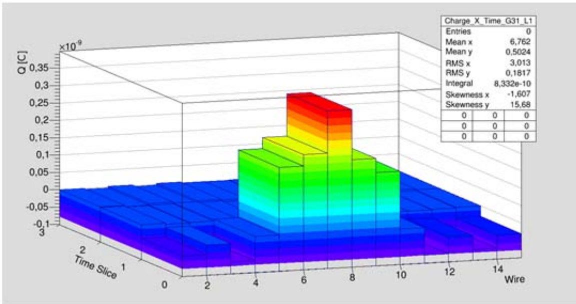

Figure 1: $^{238}U^{88+}$ profile at 125 MeV/u (fast extraction).

Further analysis of the test results will add constraints to the mechanical design of the Super-FRS SEM-grids. Effects of off-axis charge states hitting the frame and return wires were noted. Although a larger geometric coverage is required at the Super-FRS, present results ensure a standard operation along the separator.

Outlook

Further optimization, not only for the emission yield but also to increase precision of measured position and width of the beam, are foreseen. At the Super-FRS target, because of the high power absorption, different SEM material will be tested.

References

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* PSP code: 2.4.6.1.4

DOI:10.15120/GR-2015-1-FG-SFRS-03